Pulmonary rehabilitation: What, who, and when

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ABSTRACT

Pulmonary rehabilitation improves symptoms, quality of life, pulmonary function, and health-care utilization, and may improve survival in patients with chronic respiratory disease. Improving functional capacity is the most important goal of a pulmonary rehabilitation program. This is classically achieved by lower and upper extremities exercise endurance training, which improves muscle composition, increases oxidative enzyme content, and improves mitochondrial function. After exercise training, there are beneficial changes in ventilatory demand, respiratory pattern, and dynamic hyperinflation, resulting in decreased dyspnea during activities of daily living. Complementary to the exercise training, most successful programs include patient education in multiple domains. A better understanding of the disease itself, improved medication control, optimization of vaccinations, and healthy life style habits provide the patient with tools to control acute events, e.g., exacerbations. Finally, well-structured psychological support can help the patients control the symptoms of anxiety and depression that characterize respiratory diseases. Most of the evidence that supports the benefit of pulmonary rehabilitation have been derived from studies of patients with chronic obstructive pulmonary disease (COPD). However, results obtained in patients with diseases different from COPD have provided evidence that the benefits from pulmonary rehabilitation are also observed in symptomatic patients with other respiratory diseases.

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Pulmonary rehabilitation is the most effective form of therapy for symptomatic patients with respiratory diseases and with impaired functional capacity. In many randomized trials, pulmonary rehabilitation has shown to improve domains of health-related quality of life, including dyspnea, fatigue, and emotional function as well as in the 6-minute walk distance, a test of functional capacity.[1,2] These improvements have not only been statistically but also clinically significant. In addition, there is also evidence that it may decrease health-care resource utilization as well as impact on survival.[1] In this monograph, I provide a summary of this topic within the constraints of the journal's limitation in length and number of references. After a thorough review of the literature, I have selected important articles available in PubMed so the reader interested in expanding his or her knowledge in specific areas may be able to use those resources.

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DEFINITION

Pulmonary rehabilitation is defined by the American Thoracic Society (ATS) and the European Respiratory Society (ERS) as a "comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, and behavior change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors."[1] Pulmonary rehabilitation is appropriate for most symptomatic patients with respiratory disease that is impairing their quality of life.[2]

PATIENT SELECTION

Pulmonary rehabilitation should be considered in most symptomatic patients with respiratory disease that is impairing their quality of life.[3] The vast majority of studies have evaluated pulmonary rehabilitation in patients with chronic obstructive pulmonary disease (COPD) who are symptomatic, usually with a modified Medical Research Council dyspnea score of ≥ 2. This implies that the patient manifests limiting dyspnea when walking on a flat level and cannot keep up with peers. The Global Initiative for Chronic Obstructive Disease[4] recommends that pulmonary rehabilitation be included

in the management of patients with COPD who are symptomatic with functional limitations and suggests that patients with exacerbations be enrolled in such programs, because such a program in patients with moderate or severe exacerbations, because exacerbation rates are decreased in patients who have completed rehabilitation compared with usual care. Importantly, the presence of chronic stable hypercapnia is not a contraindication for pulmonary rehabilitation.

Although the evidence is not as strong as has been shown for COPD, a limited number of studies showed improvement in exercise capacity, dyspnea, and quality of life in patients with interstitial lung diseases, pulmonary hypertension, and other respiratory conditions.[1,5]

Frailty and Pulmonary Rehabilitation

Frailty can be defined as a decline in multiple physiologic systems, usually associated with aging. Practically, it can be determined by the presence of five components: weakness, slowness, exhaustion, low physical activity, and unintentional weight loss.[6] Frailty is linked to conditions such as cognitive impairment; cardiovascular disease; and, with multimorbidity, compounding health risks. In a cohort study, the prevalence of frailty among individuals with COPD was higher than in individuals without COPD and may help identify people with COPD at risk of poor outcomes.[7] Although frailty is a predictor of noncompletion of pulmonary rehabilitation, a recent study of 816 patients with stable COPD, of whom 212 (26%) met criteria for frailty, found that those who completed pulmonary rehabilitation experienced reduced dyspnea, improved exercise performance and physical activity level, and 61% no longer met criteria for frailty.[8] Thus, frailty is not necessarily a contraindication.

Contraindications to pulmonary rehabilitation are infrequent but include conditions that would place the patient at increased risk during exercise (*e.g.,* uncontrolled cardiac disease) or present obstacles to participation (*e.g.,* severe arthritis, neurologic impairment, cognitive or psychosocial disorders).[1–3]

Preprogram Evaluation

Most pulmonary rehabilitation programs require at least a spirometry before and after bronchodilator to evaluate the degree of impairment and ventilator compromise. In addition, it is informative to also measure lung volumes and the diffusing capacity for carbon monoxide, both of which will help define the physiologic reserve and potential need for specific exercise limitations. Finally, all patients should undergo exercise capacity testing (one of several clinical tests of exercise capacity may be used, such as the 6-minute walk test, the shuttle walk test, or cardiopulmonary exercise testing).[9] This evaluation will help define the precise intensity of the program, potential physiologic limitations, and therapeutic goals for each person.

Exercise Testing

The 6-minute walk test is a field test that has been standardized, is universally available, and has prognostic implications. For this test, the patient walks as far as possible during a period of 6 minutes; the total distance walked (in meters), oxygen saturation during the walk, and dyspnea are monitored. It is recommended that two walks be performed with 30 minutes rest between tests and the longest distance covered be reported. A systematic review has shown that the 6 minute walk distance improves after pulmonary rehabilitation and that >35 meters is clinically significant.[9]

An alternative test is the shuttle walk test, in which the patient walks back and forth between two cones with either a progressive increase in speed or a constant speed at 85% of a previous maximal speed. Results of studies show that the mean improvement in the shuttle walk test is 81 m (95% confidence interval, 48–115 m).[10]

Finally, cardiopulmonary exercise testing is the criterion standard of tests because it is the most comprehensive of these three tests and uses either a cycle ergometer or a treadmill to accurately measure physiologic variables such as oxygen uptake, carbon dioxide output, tidal volume, minute ventilation, electrocardiographic tracings, and pulse oximetry, and, in its most informative version, arterial blood gases and lactate levels during and at peak exercise.[11,12] The peak oxygen uptake (mL/minute) or the peak work power (watts) achieved during a cardiopulmonary exercise testing can serve as a guide to determine the intensity of the training workload to target in individual exercise training.

PROGRAM SETTING

Pulmonary Rehabilitation programs may be conducted in a hospital, outpatient, or home setting.[13] Recently, some programs that use Tele supervision have shown to work well and are being increasingly used in locations separated by long distances between the patient's home and the program site.[14] For some patients, pulmonary rehabilitation is initiated during a hospitalization for an acute exacerbation of COPD and is then complemented in the outpatient setting. It is important to know that initiating a formal rehabilitation program while the patient is in the intensive care unit was not associated with good outcomes; analysis of recent data shows that enrolling the patient after some degree of stability has been achieved (between 14 and 90 days after hospital admission) improved

outcomes compared with usual care or no rehabilitation.[15]

The number of sessions per week varies in different programs. Most outpatient programs function with 2 or 3 days/week sessions, whereas inpatient programs are usually planned for 5 days/week.[1,3] Analysis of data shows that programs that last 8 to 10 weeks (meeting three times per week) effectively achieve excellent goals, with improvement in objective and subjective testing. Programs that use virtual supervised sessions have also shown positive results and may be a way to increase the participation by patients, which continues to be the main problem with this therapy.

ESSENTIAL COMPONENTS OF A PULMONARY REHABILITATION PROGRAM

For a pulmonary rehabilitation program to achieve the best goals, it needs to integrate several components, which are summarized in Fig. 1. Although these are not all equally important, each of them improves different domains and provides the foundation for success. The most important component is the exercise training plan, without which little improvement in objective domains will be accomplished. As shown in Fig. 2, exercise training improves several physiologic domains, which results in important improvements in the overall health of the patient. Complementary components include the following: promotion of healthy behaviors (*e.g.,* smoking cessation, regular exercise, healthy nutrition, proper medication use, adherence to prescribed medications, disease self-management) and education and psychological support (*e.g.,* improving self-efficacy and providing coping strategies for chronic illness).

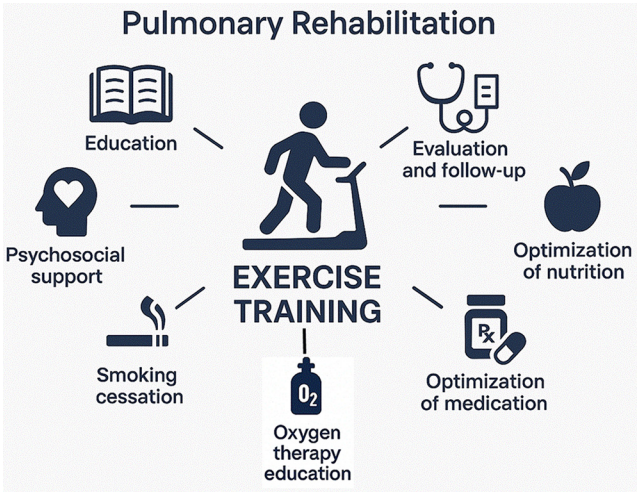

Figure 1. *Components of a pulmonary rehabilitation program. Exercise training is at the center because its inclusion results in improvement not only in patient-reported outcomes but also in the functional capacity of the individuals who complete it.*

Exercise Training

Endurance training (also known as conditioning) is the most common exercise training method used in pulmonary rehabilitation.[1–3,16] Endurance exercise can be performed by using lower and upper extremities exercises, although lower extremity training (*e.g.,* stationary cycling, treadmill, or free walking) has been better studied and is at the center of most pulmonary rehabilitation programs. In general, the training load must be greater than the loads that the patient experiences in daily life and should progress as the patient's endurance improves. Improving skeletal muscle function reduces the ventilatory demands of exercise and improves exercise capacity. Endurance exercise training with an arm or leg ergometer is typically prescribed three to five times a week with continuous exercise for 20 to 30 minutes at 60% of the individual's maximal work rate. Arm training results in task-specific improved performance, a benefit of the importance in the performance of activities of daily living.

There are several mechanisms by which exercise training improves endurance and functional capacity, some of which are summarized in Fig. 2. The benefits generally occur without a change in routine pulmonary function tests or static respiratory muscle mechanics.[17] However, rigorous studies have proven that exercise training leads to biologic and physiologic changes in the skeletal muscles and the pattern of breathing of these patients that are responsible for the observed improvement.[18,19] Biopsy specimens of the vastus lateralis muscle of the lower extremities, before and after exercise training in patients with COPD, showed an improvement in the content of oxidative enzymes.[18] Likewise, measurements made of markers of oxidative stress in the blood of patients before and after pulmonary rehabilitation during a constant load cycle ergometry have shown a decrease in those markers at the same work level.[19] The end result is that the respiratory rate and minute ventilation are decreased at the same work load after pulmonary rehabilitation, with an associated decrease in dynamic hyperinflation and dyspnea. A physiologic training effect is also supported by a lower heart rate response during constant work rate testing and is evidence of faster kinetics of oxygen consumption and carbon dioxide production.

Other less-popular training methods that have been shown to be effective include interval exercise training and resistance and/or strength training. Both of these have shown improvement in functional capacity. However, breathing retraining and ventilatory muscle training remain semi-experimental because there are some studies[20] that support their value in decreasing perception of dyspnea with exercise and when given an increased ventilator load. Unfortunately, whether this improvement in ventilator muscle function

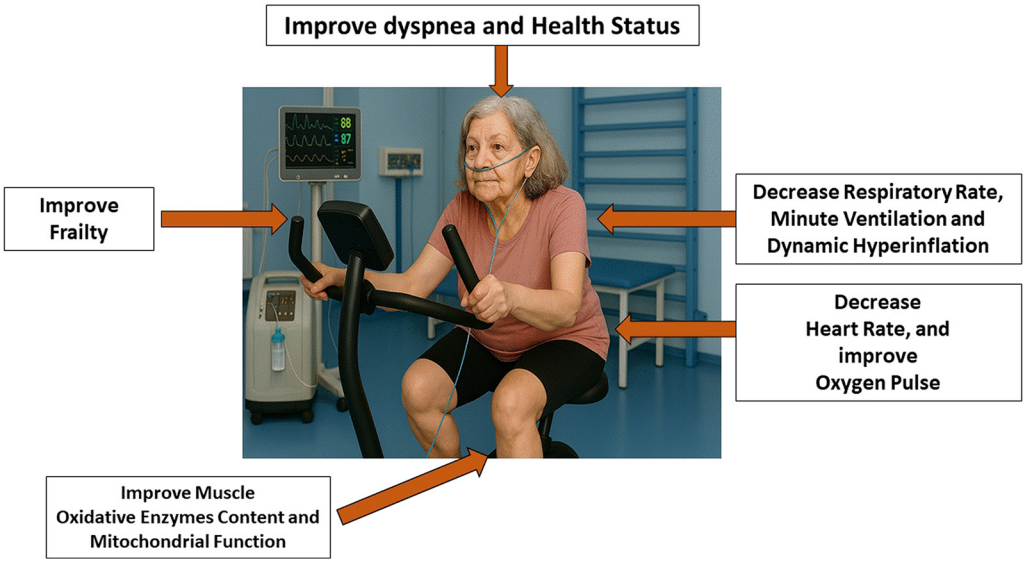
Improve dyspnea and Health Status
Improve Frailty
Decrease Respiratory Rate, Minute Ventilation and Dynamic Hyperinflation
Decrease Heart Rate, and improve Oxygen Pulse
Improve Muscle Oxidative Enzymes Content and Mitochondrial Function

Figure 2. *Summary of the beneficial changes that have been documented to occur with exercise training after completion of a pulmonary rehabilitation program. Image created by Artificial Intelligence.*

translates into improved health status has not been realized.[20]

Transcutaneous Neuromuscular Electrical Stimulation. Transcutaneous neuromuscular electrical stimulation involves electrical stimulation and contraction of individual muscles with minimal cardiorespiratory involvement. Tai chi involves a series of slow and rhythmic movements performed in a focused manner and accompanied by deep breathing. Other types of exercise training that may eventually have a role in pulmonary rehabilitation include transcutaneous neuromuscular electrical stimulation, which involves electrical stimulation and contraction of individual muscles with minimal cardiorespiratory involvement. This passive exercise can improve muscle function and could be a resource for selected persons unable to perform voluntary training. Tai chi involves a series of slow and rhythmic movements performed in a focused manner and accompanied by deep breathing. Based on two systematic reviews, on average, patients trained with tai chi improved functional capacity and pulmonary function when compared with usual care, whereas comparisons with regular pulmonary rehabilitation await completion of more studies.[21]

Table 1 **Educational material to help patients understand their respiratory condition and to implement behavior modifications that will improve their well-being**

Anatomy and physiology of respiration
Specific disease information and prognosis
Breathing strategies and secretion clearance
Role of medication, dosing, and mode of use; including oxygen therapy
Energy conservation techniques
Respiratory device use
Healthy eating habits
Daily leisure activities
Detection of exacerbations and self-management
Communication with health-care providers

Education

All patients should receive education to improve lung disease self-management (Table 1). Useful topics that will help the patient overcome fear and anxiety include programs of smoking cessation, oxygen therapy, nutrition, physical activity, proper use of medications, and health preservation (*e.g.,* vaccinations). The aim of the education program is to improve the person's understanding and knowledge of his or her health condition.[1,16] In addition, promotion of healthy behaviors, such as healthy food habits, positive interaction between the person and the environment and physical activity, can all help achieve the goals of the program.

Smoking Cessation. Smoking cessation may be difficult to achieve because of the strong psychological and physiologic dependence. Nonetheless, it should be at the center of any rehabilitation program because smoking cessation is the most beneficial therapy for long-term outcomes in any patient with respiratory disease.[1]

Nutritional Counseling and Weight Management. Attention to a healthy diet is particularly important in lung disease. Patients with lung disease are at risk for obesity due to limitations to physical activity and adverse effects of oral glucocorticoids given for exacerbations; weight loss can help reduce the work of breathing. However, a low body mass index, <21 kg/m^2, is associated with an increased risk of death. Nutritional counseling aimed at improving nutrition in these patients is indicated. These patients may benefit from smaller meals with high caloric intake ingested five times a day may be better tolerated and generate less dyspnea than the usual meals ingested three times daily.

Proper Use of Medications. Proper use of medications is particularly important with the large number of inhaled medications for COPD. It is helpful to review how the various medications work in COPD and the correct techniques for using inhalers and nebulizers. The same can be said of the use of supplemental oxygen in those patients who require it. It is very important to make sure that the patients know the risk of smoking while on oxygen. In addition, the patient should be instructed on the types of oxygen delivery devices, and logistics of traveling with oxygen.

Other components of health preservation include the potential use of action plans in case of exacerbations of the disease. Strategies for symptom control, avoidance of respiratory irritants, the importance of maintaining physical activity, and extreme importance of making sure that the patient is up to date in receiving appropriate vaccinations.

Psychological Support

Discussing goals of care and advance care planning with health-care providers and family and/or caregivers can help alleviate the fear associated with respiratory diseases. Along the same lines, life-sustaining treatments and surrogate decision-making are essential topics for patients with very severe compromise. Advance directive documents (*e.g.*, a durable power of attorney for health care [also known as health-care proxy] and a living will). The process of dying and end-of-life care can help prevent suffering when that inevitable phase of disease progression is reached.[1–3, 16]

MONITORING

During exercise training, dyspnea, breath sounds, diaphoresis, blood pressure, heart rate, and oxygen saturation are monitored. Observational trials and common sense suggest that a program of exercise maintenance should provide additional benefits compared with a return to a pre-rehabilitation lifestyle. However, in the only trial that compared the benefits of maintenance versus usual care[22] all the patients significantly improved their exercise capacity, dyspnea, and health status after the basic 8-week program. Significant differences were noted between the maintenance and control groups in the body mass index, obstruction, dyspnea and exercise capacity (BODE) index and 6-minute walk distance up to 2 years, but the benefit vanished after that time.[22] Interestingly, no difference was found in mortality between the groups over the 3 years. A different study that evaluated the impact of repeated participation in rehabilitation showed significant improvement after each of the programs in several domains.[23] A practical consequence of these studies is that, once the program is completed, it is recommended that patients adhere to a healthy lifestyle but need not continue in the just-completed program. After a prudential time (close to 2 years), *de novo* participation in the program will help patients regain lost function if it has occurred. This approach allows programs to be able to incorporate new patients and therefore decrease the usual backlog of many programs.

An alternative option is that of using digital tools to promote physical activity after completion of a regular 8-week program as supported by the results of a randomized control trial of 67 patients with symptomatic COPD. The intervention group consisted of 33 patients who were instructed and monitored in the use of a smartphone application, which consisted of an exercise training program, breathing exercises, and educational instructions. Step counts were followed up for 6 months with intermittent measures of quality-of-life and dyspnea scales. The control group also wore the activity tracker every day and used a smartphone for the step count and functional assessments but had no access to the COPD application.[24] At the end of the study, the step count was significantly higher in the intervention group compared with the control group. The intervention group also showed significant improvement in the COPD Assessment Test and in dyspnea and fatigue scores. Analysis of these results suggests that digital interventions may be useful to maintain the gains obtained after pulmonary rehabilitation, which usually reverse over time as patients tend to return to pre-rehabilitation activity levels.

A very important issue in pulmonary rehabilitation is the large proportion of patients who, being candidates for the program, do not or cannot participate. Factors found to decrease attendance include the following: current smoking, greater breathlessness, higher frequency of hospital admissions, shorter walked distance in the 6-minute walk distance, longer duration of the program (*e.g.*, 18 versus 6 weeks), and longer journey time.[25] It is possible that promoting virtual

supervised participation may help increase uptake of these programs.

BENEFITS

Patient-related outcome benefits of pulmonary rehabilitation include decreased dyspnea, improved health-related quality of life, fewer days of hospitalization, and decreased health-care utilization.[1,16] Initiation of exercise rehabilitation during or immediately after admission to a medical ward for acute or chronic respiratory failure reduces the extent of functional decline and hastens recovery. It may also reduce health-care costs, readmissions, and mortality, as long as the patient is not so ill that pulmonary rehabilitation may not offer any benefit.

Patients with COPD are likely to have additional comorbid diseases, such as hypertension, diabetes, heart failure, and coronary heart disease.[26] The presence of these morbidities, particularly metabolic diseases and heart disease, reduce the likelihood of an improved outcome after pulmonary rehabilitation.[27] However, participation in a rehabilitation program does offer the opportunity to evaluate the presence and severity of those morbidities and allows health-care providers the opportunity to optimize those treatments that can improve overall outcomes.

PULMONARY REHABILITATION IN CONDITIONS OTHER THAN COPD

Although individuals with COPD comprise the highest proportion of referrals for pulmonary rehabilitation and study participants, individuals with other chronic lung diseases, including interstitial lung disease, bronchiectasis, cystic fibrosis, asthma, pulmonary artery hypertension, lung cancer, and lung transplantation, and after coronavirus disease – 2019, also derive benefit from pulmonary rehabilitation.[28]

BARRIERS TO FULL IMPLEMENTATION OF PULMONARY REHABILITATION

Despite being eligible, only a small proportion of patients with respiratory diseases enroll in pulmonary rehabilitation programs. Multiple barriers contribute to this underutilization.[29] These include limited program availability, particularly in rural and underserved regions; inadequate reimbursement structures that fail to cover the full cost of services, thereby discouraging health-care facilities from offering pulmonary rehabilitation; and insufficient patient awareness with regard to the substantial benefits of participation. In addition, logistical challenges such as transportation difficulties, physical impairments, and comorbid conditions often hinder access. Psychosocial factors, including depression and anxiety, further diminish motivation to engage. Although global progress has been made in expanding pulmonary rehabilitation access, coordinated efforts among stakeholders committed to improving respiratory health are essential to overcome these modifiable barriers. Perhaps, the implementation of a minimal set of elements with simple equipment may decrease some of the barriers and make this very effective therapy available to more patients in need.[30]

SUMMARY AND RECOMMENDATIONS

A comprehensive program that combines exercise training, education, psychological support, and behavior modification helps improve muscle function and respiratory breathing patter, which, in turn, results in reduced breathlessness and enhanced overall quality of life. Patients often experience increased physical endurance, reduced hospital admissions, and better management of symptoms. In addition, pulmonary rehabilitation supports mental health by alleviating depression and promoting confidence in daily activities. Despite its proven effectiveness, uptake remains low due to barriers such as limited access, lack of awareness, and logistical challenges. Addressing these barriers through education and remote rehabilitation options can further expand its reach and impact.

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